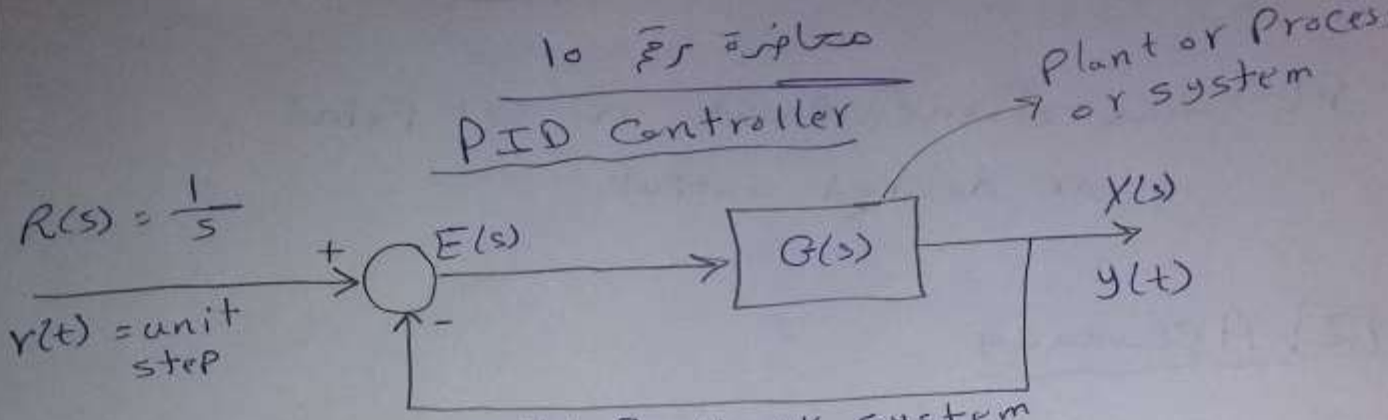
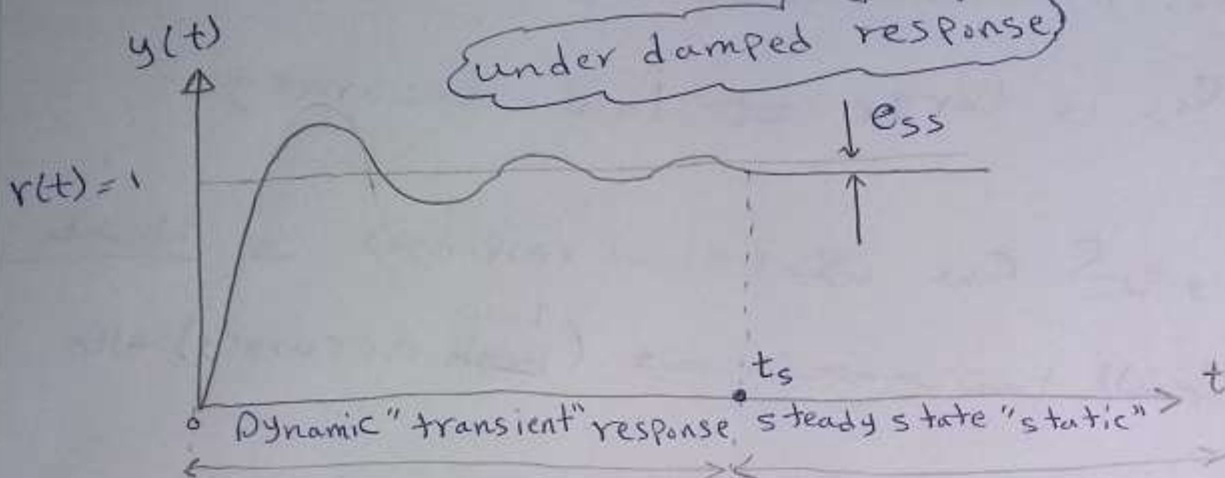
محاضرة رقم ١٠

## PID Controller




unity feedback system



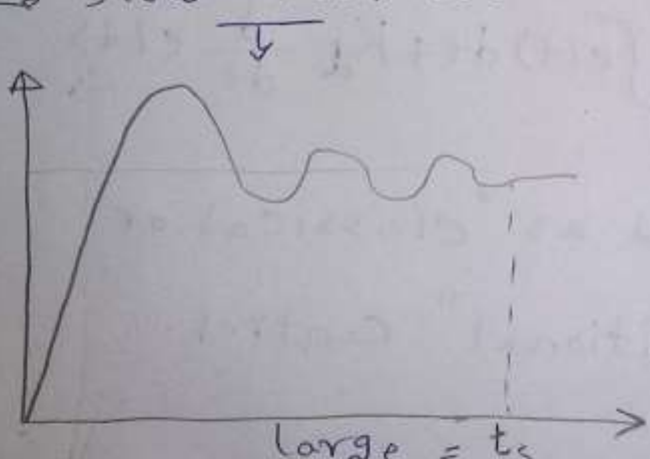

PID Controller ⟹ Proportional integral derivative

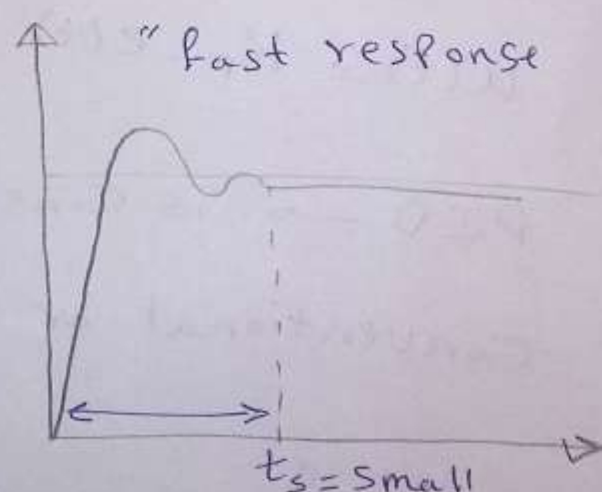
some defin

① speed of response:-

→ "slow response"

لأن $t_s$ كبيرة جداً.



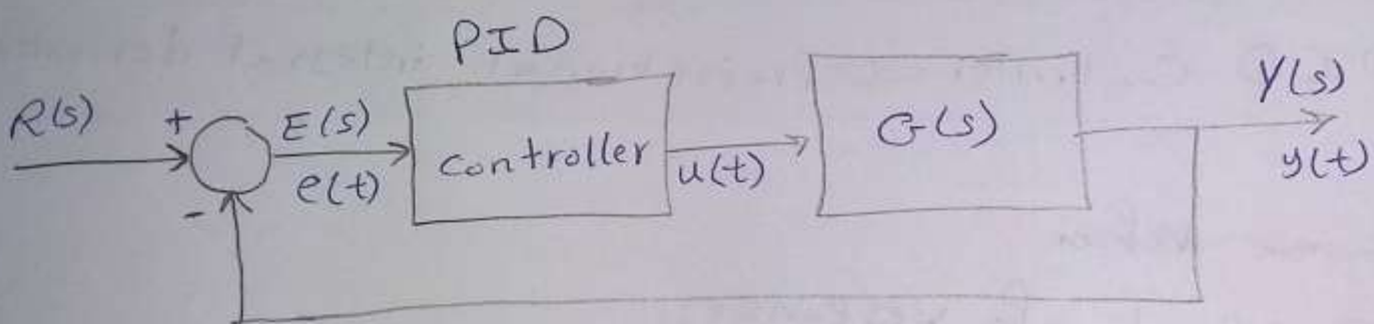
r(t) → refrence Point or set Point or desired output

## 2 Accuracy

if $e_{ss}$ is small ⇒ high accuracy.

elsif $e_{ss}$ is large ⇒ low accuracy.

ملاحظة: في (slow response) يكون $e_{ss}$ كبيرة و نواجه حالة (~~high~~ low accuracy) فيجب تحسين هذا النظام.




"Controlled system"

$$u(t) = K_p \cdot e(t) + K_i \int e(t)\,dt + K_d \frac{d}{dt} e(t)$$

PID → is Considered as "classical or Conventional or traditional" Control.

$$u(t) = \underbrace{K_p \cdot e(t)}_{\substack{\text{Proportional} \\ \text{"P"}}} + \underbrace{K_i \int e(t)\,dt}_{\substack{\text{Integral} \\ \text{"I"}}} + \underbrace{K_d \frac{d}{dt} e(t)}_{\substack{\text{derivative} \\ \text{"D"}}}$$

where:

$K_p$ is Proportional gain

$K_i$ is Integral gain

$K_d$ is derivative gain

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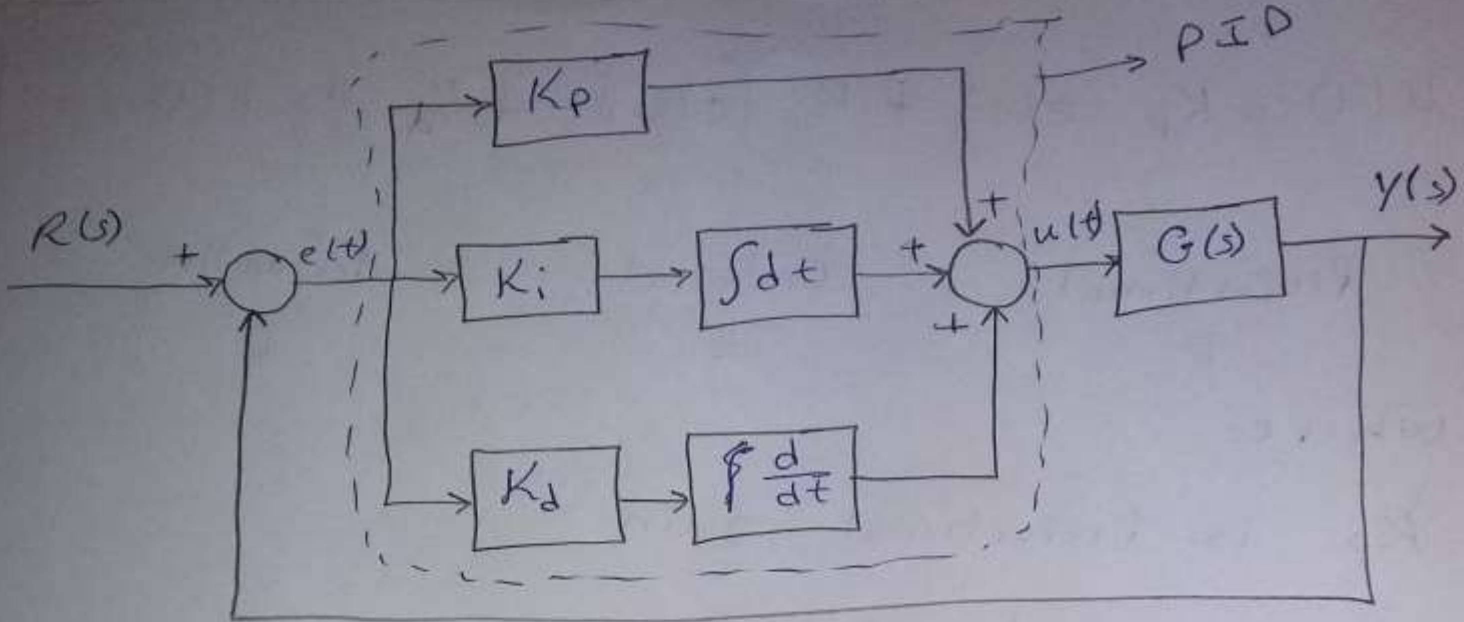
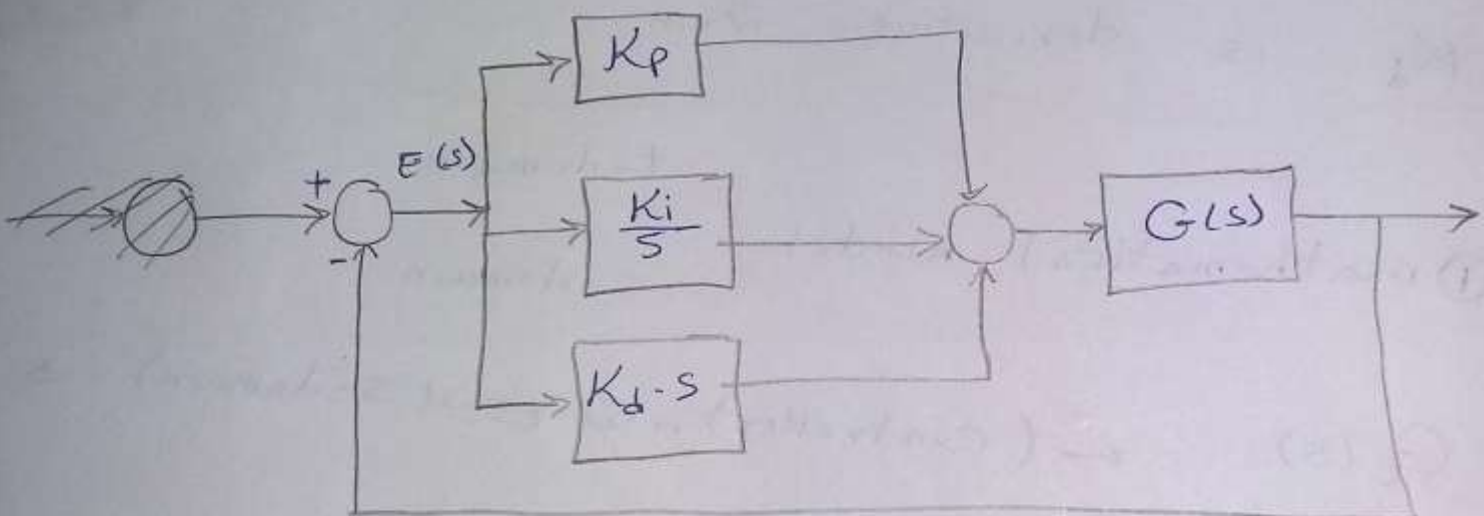
① mathematical model → t-domain, → s-domain

$G_c(s)$ ← (controller) نموذج ال(s-domain) في

$$G_c(s) = \frac{U(s)}{E(s)} = \left(K_p + \frac{K_i}{s} + K_d s\right)$$

where: $U(s) = \left(K_p + \frac{K_i}{s} + K_d s\right) E(s)$




$$u(t) = K_p\left[e(t) + \frac{K_i}{K_p}\int e(t)\,dt + \frac{K_d}{K_p}\dot{e}(t)\right]$$

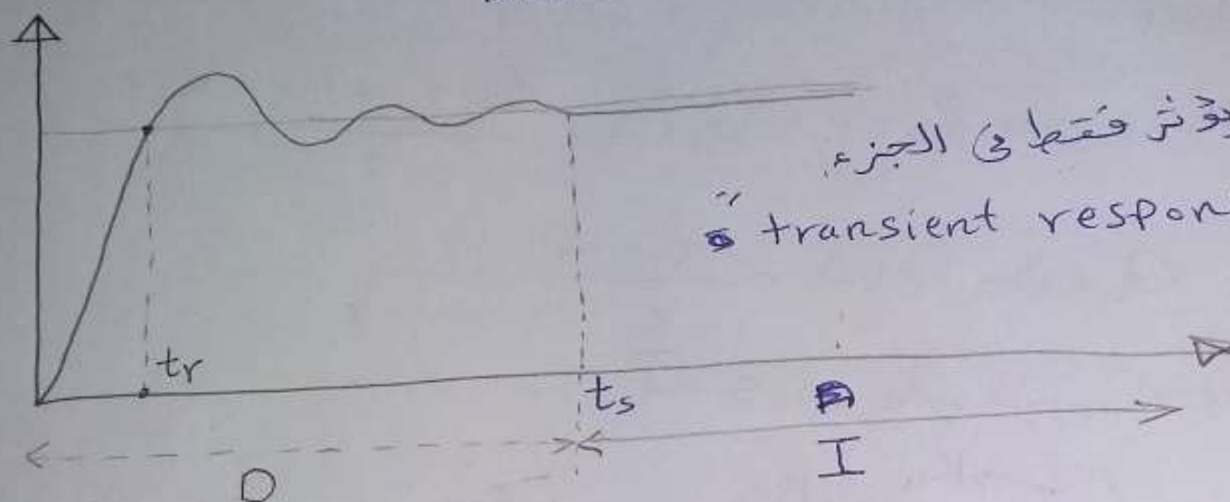
$$= K_p\left[e(t) + \frac{1}{T_i}\int e(t)\,dt + T_d\,\dot{e}(t)\right]$$

where: $T_d = \frac{K_d}{K_p}$ $\longrightarrow$ derivative time

$T_i = \frac{K_p}{K_i} \longrightarrow$ integral time.

$$G_c(s) = \frac{U(s)}{E(s)} = K_p\left[1 + \frac{1}{T_i}\frac{1}{s} + s\cdot T_d\right]$$

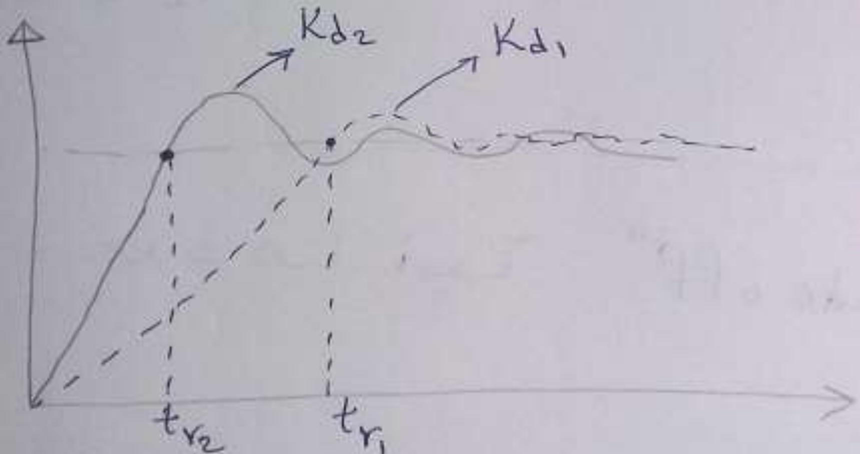
أولاً تأثير "Derivative Part"




يؤثر فقط في الجزء ←

"transient response"

$K_{d_1}\uparrow\uparrow \quad \therefore t_{r_1}\uparrow$ ، $K_{d_2}\downarrow\downarrow \quad t_{r_2}\downarrow$




$K_{d_2} < K_{d_1}$

as $K_d\uparrow\uparrow$ it reduce oscillations

but it made rise time $t_r\uparrow\uparrow$ → we call this trade off.

← ثانياً الجزء " Integral "

← يقلل من $e_{ss}$

Note

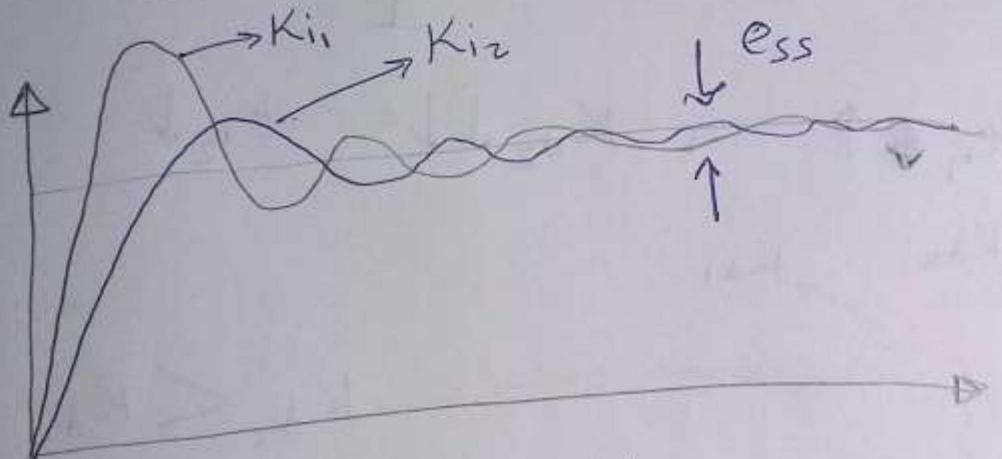
$$G(s) = \frac{(\ )(\ )}{s(\ )(\ )}$$

$s$ ← system type

Here we face : $G_c(s) = \dfrac{K_p s + K_i + K_d s}{s}$

$$\therefore G_c(s) \cdot G(s) = \frac{(\ )\ (\ )}{s\ (\ )}$$

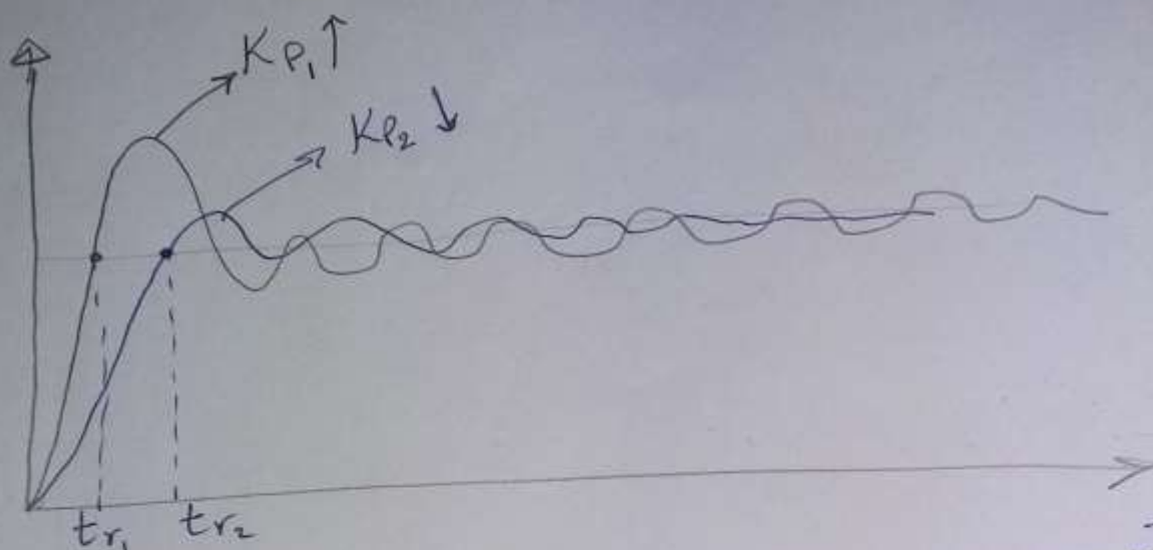
$s$ ← دى تأثير الجزء "integral"




$K_{i_2} < K_{i_1}$

← حدث هنا أيضاً " trade off "

← الجزء "Proportional" يؤثر ع transient and steady state




$K_{P_1} \uparrow\uparrow \Rightarrow t_{r_1} \downarrow$ oscillations is too much

$K_{P_2} \downarrow\downarrow \Rightarrow t_{r_2} \uparrow$ oscillations is reduced

$K_{P_2} < K_{P_1}$

$\boxed{7}$ Lec 15